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MOTOR FLUID DRIVE, ESPECIALLY FOR ROTARY, PIVOTAL OR LINEAR DRIVE UNTIS AND CORRESPONDING METHOD

Description

The invention concerns a drive, in particular, for rotary, pivotal or linear drive units, comprising a working piston which is housed in a cylinder of a housing and can be loaded by fluid pressure media, as well as displaced in an axial direction. The invention also concerns a rotary, pivotal or linear drive unit comprising such a drive and a method for operation thereof.

Drives of this type are widely used in automation systems, since they have a very high power density due to the fluid, in particular, pneumatic pressure media. The piston of linear drive units is connected, either directly or indirectly, to e.g. a gripping means. The gripping means is also moved in an axial direction through the axial motion of the piston. The working piston of rotary or pivotal drive units may be operatively connected, via a rotary coupling, to a pivot part which is rotatably disposed in the housing. The motion of the piston in an axial direction thereby pivots the pivot part. The pivot part may e.g. have gripping means for gripping and pivoting workpieces.

Shock absorbers are conventionally used to move the piston to a certain target position to decelerate or delimit the linear motion of the working piston in the axial direction. The use of shock absorbers has many disadvantages. In particular, the shock absorbers cannot withstand the high loads at high pressures, and are disadvantageously subject to wear. For this reason, shock absorbers cannot provide reproducible damping rates on a long-term basis.

Shock absorbers are also relatively expensive, occupy space in or on the drive and restrict the power of the drive.

The use of shock absorbers is also disadvantageous in that the piston or the load moved by the drive cannot be moved to any position and can therefore not be disposed at any position. Positioning therefore requires appropriate mounting of a shock absorber or associated stop at a certain location. The position of the shock absorber or stop must therefore be changed to change positioning. The above-described conventional drives therefore lack flexibility.

It is the underlying purpose of the present invention to further develop a drive of the above-mentioned type which ensures high power density and increases the positioning capability and thereby the flexibility of the drive.

This object is achieved with a drive of the above-mentioned type by disposing mechanical coupling means on the drive piston, which can be coupled to a motor, such that the motor can decelerate and/or drive the drive piston in an axial direction.

The working piston can be decelerated or driven at almost any position by using a motor which drives and/or decelerates the motion of the working piston in an axial direction via the coupling means. This increases the flexibility of the drive. The working piston can be freely positioned and be stopped and/or started at any position. Corresponding shock absorbers or stops that effect movement to a target position can be omitted. Motion towards a target position can be achieved through corresponding deceleration of the motion of the working piston.

Precise driving or deceleration of the working piston by the motor moreover realizes fine positioning or fine adjustment of the position of the working piston in the cylinder, and thereby exact positioning of the load to be moved. In accordance with the invention, the motor, which may be designed as an electromotor, is therefore suited to move the working piston to a target position, i.e. decelerate or drive it, and optionally move it to the target position in a fine adjustment mode.

There are conventional drives in automation systems, with which a rotary motion generated by an electromotor is transmitted into a linear motion, e.g. by a spindle drive or a toothed rack drive. This drive is advantageous i.a. due to free selection of position of the moved load and fast response thereof. The very small power density is, however, disadvantageous. Very powerful motors requiring a correspondingly large amount of space are required to dynamically move large loads. The mechanical coupling means thereof must moreover withstand large forces due to large loads and are therefore subjected to great wear.

The inventive combination of a fluid drive having high power density, and coupling of the working piston to a motor for driving and/or decelerating the working piston combines the advantages of fluid and, in particular, electric drives in a novel fashion. The high power density of a fluid drive is maintained and the flexibility of motor drive is additionally utilized.

A gas, such as e.g. air, or a hydraulic fluid, such as e.g. hydraulic oil, may be used as the fluid.

In a particularly advantageous embodiment of the invention, the mechanical coupling means comprise a spindle nut or spindle rod disposed on the working piston and a spindle rod or spindle nut which can be driven by the motor. The motor may thereby be operatively connected to the

spindle nut or spindle rod either directly or indirectly, e.g. via a transmission. A circulating ball spindle may, in particular, be used. The use of a spindle rod/spindle nut improves the transmission ratio through which the working piston can be correspondingly driven or decelerated. A spindle nut or spindle rod may moreover be advantageously disposed on the piston, in particular, on one of its front ends. The spindle rod penetrates through the corresponding cylinder space and is operatively connected to the motor on the side facing away from the piston. No additional space is therefore required.

In accordance with another embodiment of the invention, the mechanical coupling means may comprise a toothed rack which is disposed on the working piston, and a pinion which can be driven by the motor. This also realizes advantageous driving or deceleration of the working piston in an axial direction. The toothed rack thereby advantageously penetrates through the cylinder space in an axial direction. No additional space is thereby required.

In accordance with the invention, the mechanical coupling means may also comprise a worm wheel which is rotated by the working piston via a rotary coupling, and a pinion that mates with the worm wheel and can be driven by the motor. This embodiment provides compact construction, in particular, in the longitudinal direction.

In order to obtain compact construction, the motor may be flanged to the housing. The housing and/or the motor may have corresponding flange sections. The motor may, however, also be designed as a hollow shaft motor which may be disposed at least partially within the working piston.

In a preferred embodiment of the invention, a regulation and/or control unit is provided which drives the motor in dependence on the position

and/or the temporal change of position of the working piston and/or the respective pressure and/or the temporal change of the respective pressure in the pressure chambers of the cylinder. It may be driven e.g. with the aid of measuring systems which directly detect the position of the working piston or the position of an element which is motionally coupled to the working piston, e.g. a gripping means. The regulation and/or control unit may advantageously be programmed. Towards this end, predetermined target positions can be set which are then approached by the working piston through loading the working piston using pressure media and decelerating and/or positioning the working piston using the motor. When the working piston is moved by loading the piston, the motor also rotates freely without current or supports the motion caused by pressure load.

In accordance with the invention, a regulation and/or control unit may be provided, which directly drives the respective pressure in the pressure chambers of the cylinder when a limit load of the motor has been reached, such that the load on the motor is reduced and/or the motion of the working piston effected or controlled by the motor is supported. When the working piston reaches a predetermined target position, the motion of the working piston can be controlled by reducing the pressure in the corresponding pressure chamber, by loading the working piston with a counter pressure and/or by decelerating the motion through corresponding control and current supply to the motor. When an excessive load acts on the motor, the pressure chambers are driven such that the motion of the working piston is supported by the motor, thereby reducing the load acting on the motor. The motion of the motor is therefore power-assisted. This is advantageous in that a relatively small motor can be used for precise motion towards the target positions of the working piston, even when the working piston bears high loads.

The load acting on the motor can e.g. be determined by monitoring the motor current accepted by the motor. A torque sensor may also be provided on the motor shaft for determining the motor torque and thereby the load acting on the motor. The load may also be determined by the reaction moment of the motor, e.g. using corresponding sensors on the motor bearing or through detecting the amplitude of a rotatably borne or freely suspended motor.

It has turned out to be advantageous for the coupling means to have a high transmission ratio. A high transmission ratio permits use of motors having small dimensions, in particular, electromotors with low torque. The transmission ratio transforms the low output torque of the motor into a correspondingly large torque. For this reason, small motors can withstand even relatively high pressures in the cylinder space. The motion of the working piston can thereby be decelerated.

An advantageous drive is characterized in that it is suited for a rotary or pivotal drive unit, wherein the working piston is operatively connected, via a rotary coupling, to a pivot part which is rotatably disposed in the housing. One advantage of these drives is that the pivot part can be precisely decelerated in any pivot piston, i.e. at any angle of rotation.

The above-mentioned object is also achieved by a rotary, pivotal or linear drive unit comprising an inventive drive.

The invention also concerns a method for operating an inventive drive and/or an inventive drive unit, wherein, upon loading the cylinder for moving the working piston, the motor is also rotated at least largely without load, or supports the motion of the working piston, wherein, upon or shortly before reaching the target position of the working piston, the motor is driven to decelerate the motion of the working piston. The

pressure in the cylinder may, in particular, thereby be correspondingly reduced or a counter pressure be built up in the corresponding pressure chamber. The corresponding pressure chamber may also be kept pressure-free. Deceleration is effected in such a manner that the working piston reaches the target position.

Further features and details of the invention can be extracted from the following description which describes and explains the invention in more detail with reference to an embodiment shown in the drawing.

Fig. 1 shows a longitudinal section through a first inventive drive; and

Fig. 2 shows a second embodiment of the invention.

Fig. 1 shows a longitudinal section through an inventive drive 10. The drive 10 may be provided for a rotary, pivotal or linear drive unit. The drive 10 comprises a cylinder 12 in a housing 14. The cylinder 12 is shown as a one-piece, continuous cylinder. In accordance with the invention, the cylinder 12 may also comprise several cylinder sections each being formed by a cylinder tube. A working piston 16 is disposed in the cylinder 12 and divides the cylinder 12 into two pressure chambers 18 and 20. The pressure chambers 18 and 20 can be loaded with a pressure medium on alternating sides, such that the piston 16 moves in an axial direction. The piston 16 is coupled either directly or indirectly to means which are suited to move workpieces. When the drive 10 is used in a linear drive unit, the workpieces are linearly moved along one direction.

When the drive 10 is used in a rotary or pivotal drive unit, the working piston 16 is advantageously operatively connected to a pivot part which is rotatably disposed in the housing 14 via a rotary coupling (not shown).

When the working piston is moved in an axial direction, the pivot part is rotated/pivoted.

A spindle nut 22, which is connected to the working piston 16 such that it cannot rotate relative thereto, is provided on a front end of the working piston 16. A spindle rod 24 is rotatably disposed in the spindle nut 22, whose free end 26 facing away from the piston 16 is disposed on a drive shaft 28 of an electromotor 30. The spindle rod 24 can therefore be rotated by the electromotor 30. When the spindle rod 24 is rotated, the working piston 16 can be moved in an axial direction by the spindle nut 22 which cooperates with the spindle rod 24. The spindle nut may, of course, also be rotatably coupled to the output shaft 28 of the electromotor 30. In this case, the spindle rod 24 is disposed on the piston 16 such that it cannot rotate relative thereto.

The spindle rod 24 and the spindle nut 22 form mechanical coupling means via which the motor 30 drives or decelerates the motor 30 in an axial direction.

The transmission ratio between the spindle rod 24 and the spindle nut 22 may thereby be such that self-locking between the spindle rod 24 and the spindle nut 22 is prevented. This ensures free rotation of the spindle shaft 24 when the piston 16 moves due to loading of the pressure chambers 18 or 20. The motor 30 is preferably switched off in this case. The rotor of the motor 30 rotates without being loaded.

The transmission ratio is moreover sufficiently high, such that an electromotor 30 having relatively small dimensions can be used to decelerate the motion of the piston 16.

The drive 10 advantageously comprises a regulation and control unit (not shown) which appropriately regulates the pressure load on the pressure chambers 18 and 20 and the electromotor 30 drive. Shortly before reaching a freely predetermined target position of the working piston 16, the pressure in the corresponding pressure chamber 18 or 20 can be reduced or a corresponding counter pressure can be built up and the electromotor 30 can be driven such that the motion of the working piston 16 is decelerated, thereby ensuring that a predetermined target position of the working piston 16 or a means connected to the working piston 16 is reliably reached. Measuring systems are advantageously provided which either detect the actual position of the working piston 16 or the actual position of a means coupled to the working piston 16.

The inventive drive 10 is advantageous in that it has high power density and also provides free and highly flexible positioning of the working piston 16 and of the load moved thereby. The high power density is achieved by pressurizing the pressure chambers 18, 20. High loads can be moved at high piston speeds, thereby still ensuring high flexibility. The mechanical coupling means and the electromotor 30 can freely position high loads.

When a predetermined target position of the working piston 16 has been reached, the motion of the working piston 16 is controlled by reducing the pressure in the pressure-loaded pressure chamber or by loading the working piston with a counter pressure and/or by decelerating the motion through corresponding drive and current supply to the motor 30. When the load acting on the motor 30 is excessively large, the pressure chambers 18, 20 are driven in such a manner that the motion of the working piston 16 is supported by the motor 30, thereby reducing the load acting on the motor 30. The motion of the motor 30 is thereby power-assisted. The load acting on the motor may e.g. be detected by a torque sensor on the motor shaft.

Fig. 2 shows a pivotal drive 32 comprising two working pistons (not shown) which are housed in the cylinders 12 of a housing 14 and can be loaded by fluid pressure media and be displaced in an axial direction. Mechanical coupling means are provided on the working piston, which are coupled to the motor 30 in such a fashion that the working piston can be decelerated and/or driven by the motor 30. The mechanical coupling means thereby comprise a worm wheel 34 which is rotatably disposed, via a rotary coupling, in the housing (12) with the working piston and/or its piston rod, and a worm 36 which mates with the worm wheel 34 and can be driven by the motor 30.